

NovA Note  
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## **Light-Sealing of NovA PVC Extrusions via Painting**

### **Overview:**

The PVC extrusions to be used for the NovA experiment are translucent, e.g. the illumination from a flashlight can be observed through the walls of Most extrusions. Thus ambient light from the laboratory environment may enter the detector through some cells along the detector's outer surface, thereby adding to the noise rate of the electronics readout. This problem has been examined by Leon Maulem and results are reported in docDB 378. The situation vis-a-vi NovA extrusions is summarized thusly:

``For typical lighting intensities approximately 20 attenuation lengths of material are required to reduce the induced dark current to less than 10% of the typical APD dark current, implying a required thickness of 3.0 to 3.8 mm.

... For greater margin of safety, insensitive to lamp directly on the device, we need about 50x more attenuation, or ~24 attenuation lengths, 3.8 to 4.6 mm."

While alternative approaches to this problem have been voiced at NovA meetings such as adding a blackener into the extrusions or outfitting exterior portions of the detector with black-felt covers, the most straightforward solution is to paint the specific PVC surfaces by which ambient light can enter. These include the area between the horizontal and vertical modules on the top and on the sides of the NovA far detector.

An exploratory trial with a commercially recommended paint highlighted certain potential problems, as follows: It is highly desirable that any PVC surface treatments be devoid of acetones or other ingredients which release noxious fumes, consequently the acceptable choices for primers are restricted. It was observed that good surface adhesion may not be readily achieved with PVC, and that some specialty treatments for PVC are quite expensive for large-area application.

## **Painting R&D at Tufts University:**

Following consultations with David Ayres (ANL) and Karen Kephart (FNAL), the Tufts group collected information concerning surface treatment of PVC. Information sources included vendors for painting tasks frequently used by Tufts University, a web search, and advice gleaned from general contractors contacted through the Physics - Engineering shop. The general picture that emerged from these contacts is that applications for PVC in home-building, especially in plumbing, has surged during the past decade, and there has been intense competition for primer-topcoat treatments for PVC. Consequently there are suitable products which are readily available at modest cost.

The relative ruggedness of paint surface treatments for PVC, that is, the degree to which scuffing or scraping can be tolerated without exposure of the PVC, depends to large extent upon the primer. There are primers which ``cover" the PVC without interacting with it; these generally have benign ingredients. More rugged treatments use primers which modestly etch the PVC surface; these generally have a few percent of acetone or xylene and require precautions with ventilation to avoid health hazards. Since the NovA application is intended as a light-seal on surfaces which will not be subjected to frequent, energetic scuffing, the ruggedness afforded by primers of the ``cover" type is found to be adequate, as is described below.

Information-gathering was pursued for several weeks, after which time all primer-plus-topcoat combinations which had been recommended or mentioned were compiled. The ingredients of primers and of topcoat paints - to the extent they could be gleaned from product data-sheets - were compared. Our compilation identified six different primer-plus-topcoat combinations as being plausible surface treatments for NovA PVC. One-gallon samples of each of the candidate primers and topcoat paints were then purchased; the total cost including brush applicators and cleaning solvents was less than \$ 500.

Each candidate primer-plus-topcoat combination was then applied to sample PVC extruded pieces or ``pallets" provided by Argonne National Laboratory. Each surface treatment was applied to a PVC pallet surface of ~ 4 sq ft area. In each of the six trials, the primer was applied using a brush and allowed to set overnight; subsequently half of the primer surface was brush-coated with its matching topcoat. Among the six candidate treatments, three of the primers can only be purchased as color white. When these primers were being applied, we

found it troublesome to keep tabs of which portion of a (white) PVC surface was covered, and so we experimented with tints. In all cases we found that tinting could be done to the primers without detriment to surface treatment. The time allowed for each primer to dry (12 hours) was conservative by intention. Subsequent trials showed that two hours is a sufficient drying interval for all primers used in our six treatment combinations.

#### **Primer-plus-Topcoat Trials; Favored Combination:**

The Table below summarizes the six primer-plus-topcoat PVC surface treatments which were tried. A photograph of one of the PVC pallets with surface treatments is included in the NovA Collaboration Meeting talk which summarized this work (February 9, 2007: docDB 1374); samples of each surface treatment were circulated at that Meeting.

<b>Sample #</b>	<b>Primer</b>	<b>Type</b>	<b>Price</b>	<b>Topcoat</b>	<b>Price</b>
<b>1</b>	BIN	shellac-base	\$32/gal	Rust-oleum (oil base flat black enamel)	\$25/gal
<b>2</b>	XIM	solvent-based bonder	\$42/gal	Rust-oleum (oil base flat black enamel)	\$25/gal
<b>3</b>	TUFF	solvent-based synthetic rubber	\$45/quart	TUFFCOAT	\$45/quart
<b>4</b>	KILZ	oil base, tint added (1% xylene )	\$15/gal	Benjamin Moore (oil base flat blk enamel)	\$25/gal
<b>5</b>	KILZ	oil base (1% xylene )	\$15/gal	Benjamin Moore (oil base flat blk enamel)	\$25/gal
<b>6</b>	KILZ-2	latex	\$15/gal	Benjamin Moore (oil base flat blk enamel)	\$25/gal

All of the above-listed surface treatments yield a light-seal coating which is rugged by normal household standards.

Surface treatment #3 is an example of synthetic rubber primers designed for coating e.g. rubber rafts but also advertised as excellent for PVC. The cost of this treatment is distinctly higher than the others (note that the costing listed is per quart rather than per gallon), making it undesirable for NovA application. Surface treatments #1 and #2 require primers which are also relatively expensive. Treatments #4, #5, and #6 are marketed for household applications; treatments #4 and #5 contain xylene, whose presence is immediately discernible via smell when primer is applied. In contrast, treatment #6 uses a latex primer together with a conventional oil base enamel topcoat. The cost per gallon is among the lowest, all ingredients are benign, and it yields a surface light-seal of adequate ruggedness.

### **Response of Surface Treatments to Liquid Scintillator Spillage:**

When the detector is being filled with liquid scintillator, it is likely that modest spillage will occur, resulting in painted PVC sections being sprinkled with liquid. While the liquid scintillator is 94.4% mineral oil (mass fraction) which does not interact with surface treatments, the pseudocumene additive (5.5%) is potentially deleterious to most surface treatments if it remains in contact over some period of time. Fortunately, pseudocumene evaporates rather quickly, hence it is not straightforward to predict the extent to which scintillator spillage poses problems to a light-sealing surface treatment.

The response of each of the six candidate surface treatments to liquid scintillator spillage was tested in the Tufts shop. For this purpose, a gallon of NovA grade liquid scintillator was obtained from Indiana University. For each treatment, 1 ft. x 6 in. patches of PVC extrusion covered by i) the primer only, and ii) the primer-plus-topcoat were exposed to liquid scintillator droplets and were monitored over a 48-hour period. The same benign outcome was observed with all six of the treatments listed including treatment #6: The liquid scintillator remained pooled atop the various surface treatments without permeating into them. A degree of evaporation of the liquid scintillator was apparent after the initial twelve hours. After 48 hours small puddles of liquid could still be seen. These were readily removed by wiping with a dry cloth. In no cases was black topcoating observed to be removed by the wiping.

We conclude that none of the above-listed surface treatments, including treatment #6, is noticeably compromised by spillage of NovA-standard liquid scintillator.

## **Cost Estimate for Paints to Light-Seal the NovA Far Detector:**

The industry-standard rule-of-thumb for commercial applications of primers and topcoats is that one gallon covers 550 square feet. However one needs to allow for overspray/wastage; for either brush or spray-on application an allotment of 20% is appropriate. Thus we use one gallon = 440 square feet to construct our estimate.

### **I. Light Seal of the Top of the Detector:**

The extrusion cells to be treated are 2.6 inches wide and 52 feet in length. The seal will need to extend modestly beyond the cell corners, hence we allow 3 inches by 52 feet or 13 square feet per horizontal cell along the top. There are 650 horizontal planes, consequently the top area to be treated is 8,450 square feet. Then we have (rounding upward to the nearest gallon):

$$(8,450 \text{ sq ft}) / (440 \text{ sq ft / 1 gallon}) = 20 \text{ gallons.}$$

Using surface treatment #6, the cost for the light-seal is

Primer:	20 x \$15/gallon = \$ 300.
Topcoat:	20 x \$25/gallon = \$ 500.
Task consumables: (applicators, solvents, gloves, etc)	\$ 200.
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TOTAL:	\$ 1,000.

Allowing for task setup and subsequent cleanup, we estimate that 1 FTE applies one gallon of paint in five hours on average. Thus light-sealing the top of the detector requires  
 $40 \times 5 = 200$  FTE hours.

## II. Light Seal of the Sides of the Detector:

Along the detector sides, there will be on-average a six-inch section to be light-sealed for each plane. There are two sections per east side of the plane and two sections per west side, hence 104 square feet per plane. There are 650 planes, so the area to be treated on the sides totals 67,600 square feet.

$$(67,600 \text{ sq ft}) / (440 \text{ sq ft / 1 gallon}) = 154 \text{ gallons.}$$

As previously, using surface treatment #6, the cost for the light-seal is

Primer:	154 x \$15/gallon = \$ 2,310.
Topcoat:	154 x \$25/gallon = \$ 3,850.
Task consumables: (applicators, solvents, gloves, etc)	\$ 800.
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TOTAL:	\$ 6,960.

The detector sides require 308 gallons of surface treatment. Assuming that 1 FTE applies one gallon per five hours (rate-average over total task) we estimate that  $308 \times 5 = 1,540$  FTE hours are required to light-seal the detector side surfaces.